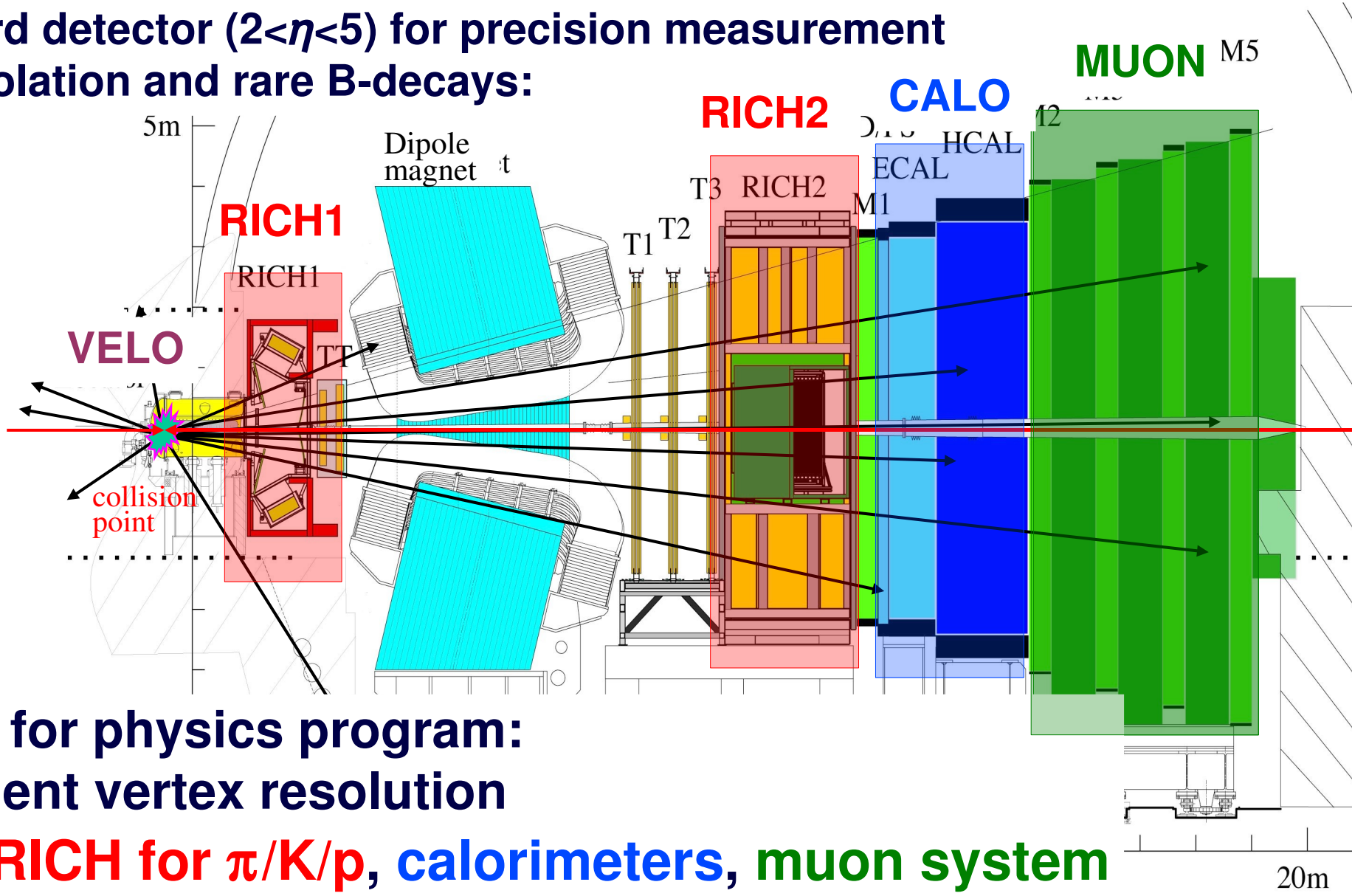
Particle ID and baryon production asymmetries from LHCb

Susanne Koblitz (CERN)
on behalf of the LHCb collaboration

22nd Rencontres de Blois 2010
15th - 20th July 2010

LHCb Detector Layout

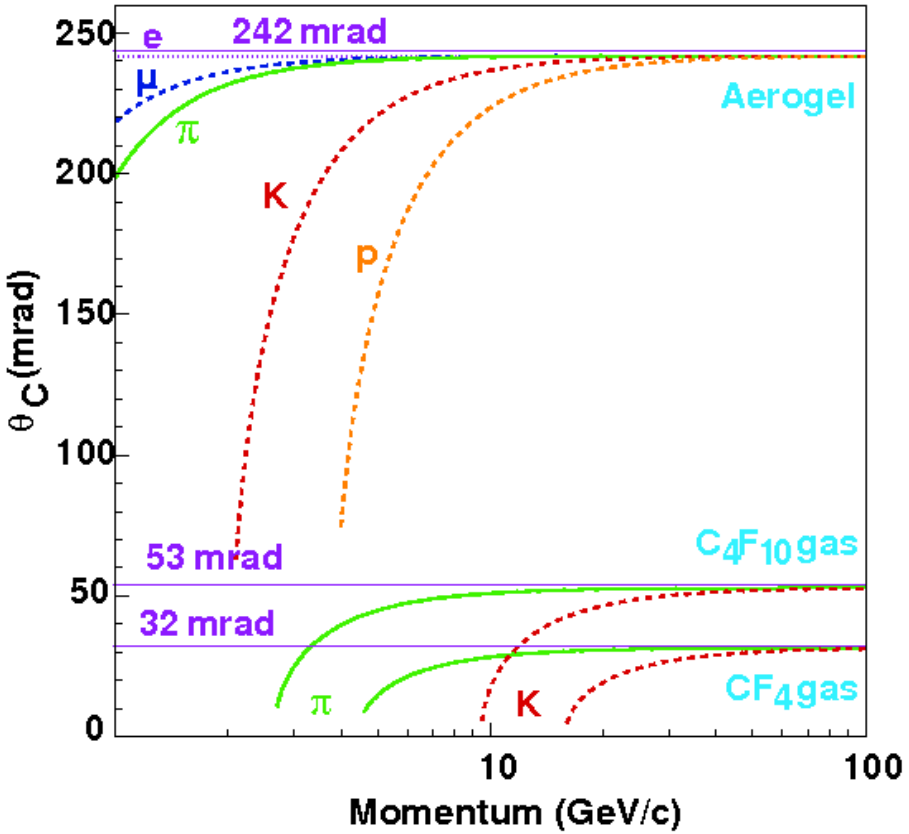
A forward detector (2<η<5) for precision measurement of CP violation and rare B-decays:



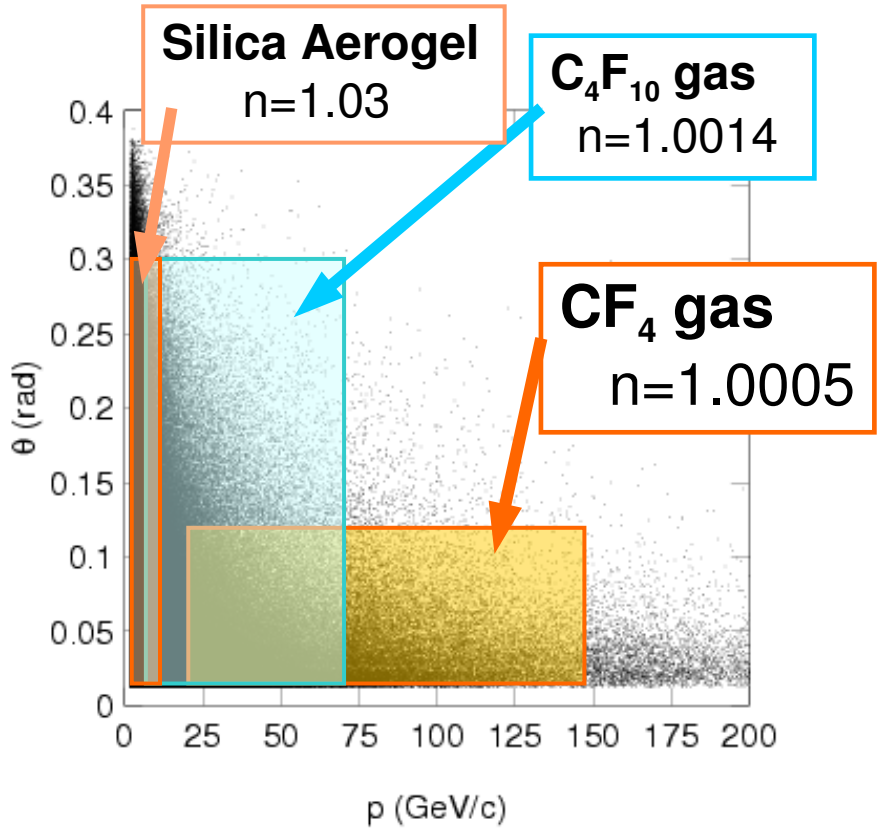
Crucial for physics program:

- **excellent vertex resolution**
- **PID: RICH for π/K/p, calorimeters, muon system**

The RICH Detectors



Need good π/K/p separation in momentum range between 1 and 100 GeV and good coverage of angular acceptance



2 Detectors, 3 Radiators!

Angular Acceptances

RICH1:

25→250 mrad vertical

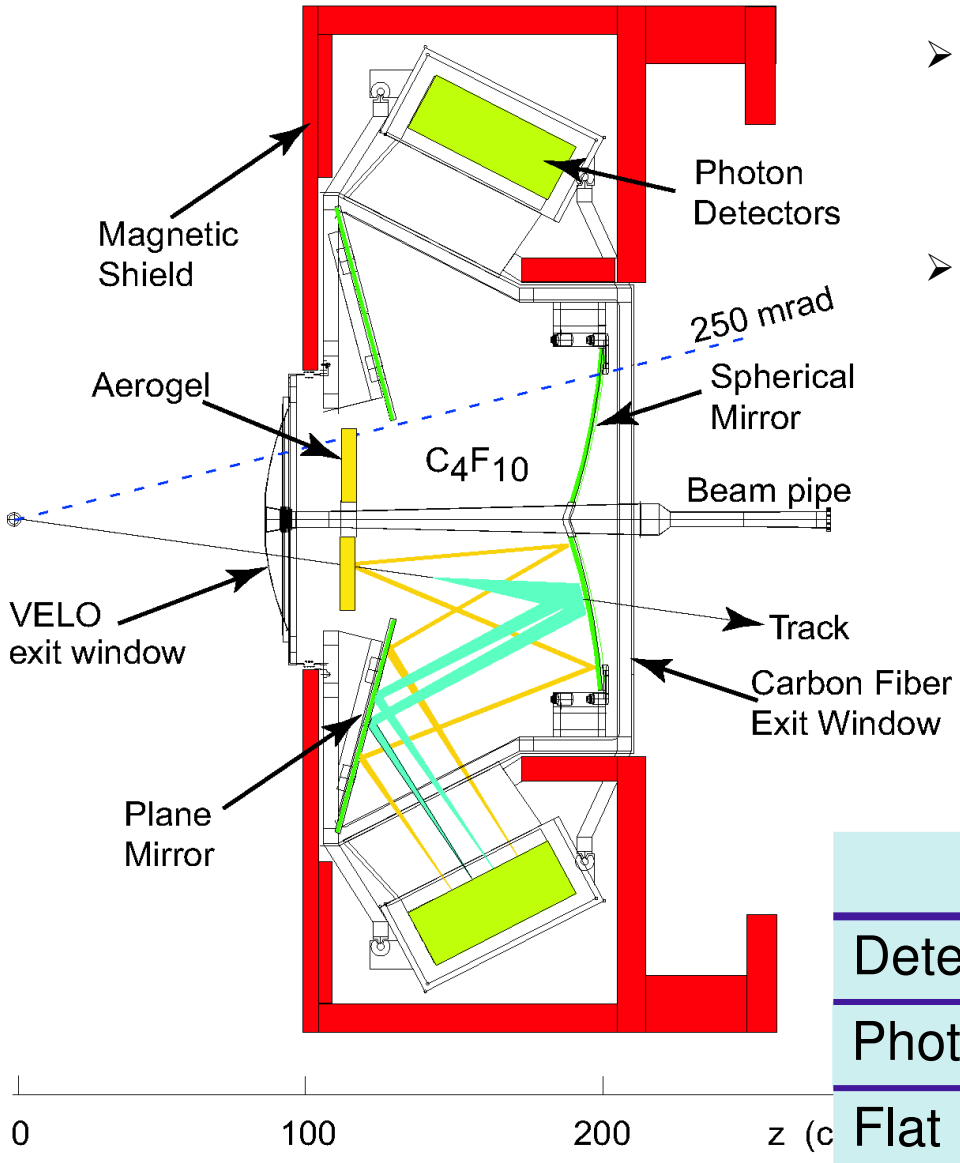
25→ 300 mrad horizontal

RICH2:

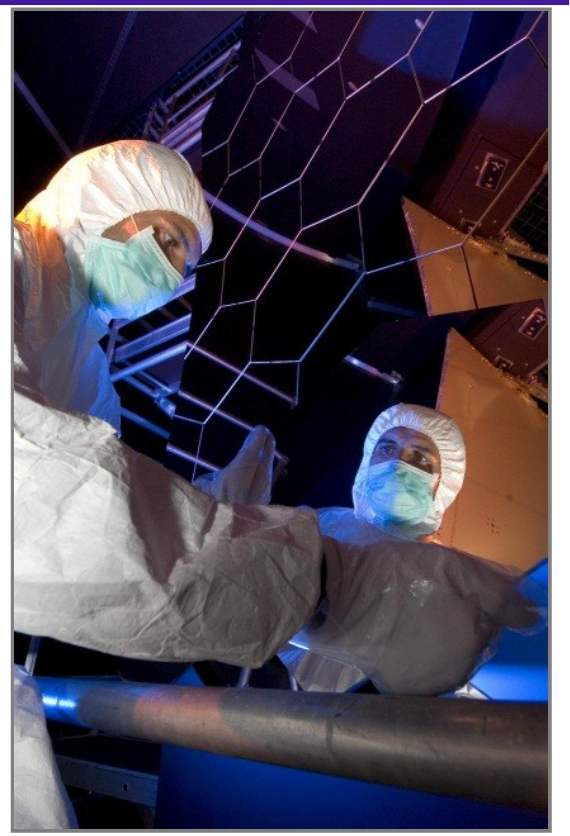
15→100 mrad vertical

15→ 120 mrad horizontal

RICH1 & RICH2: more details



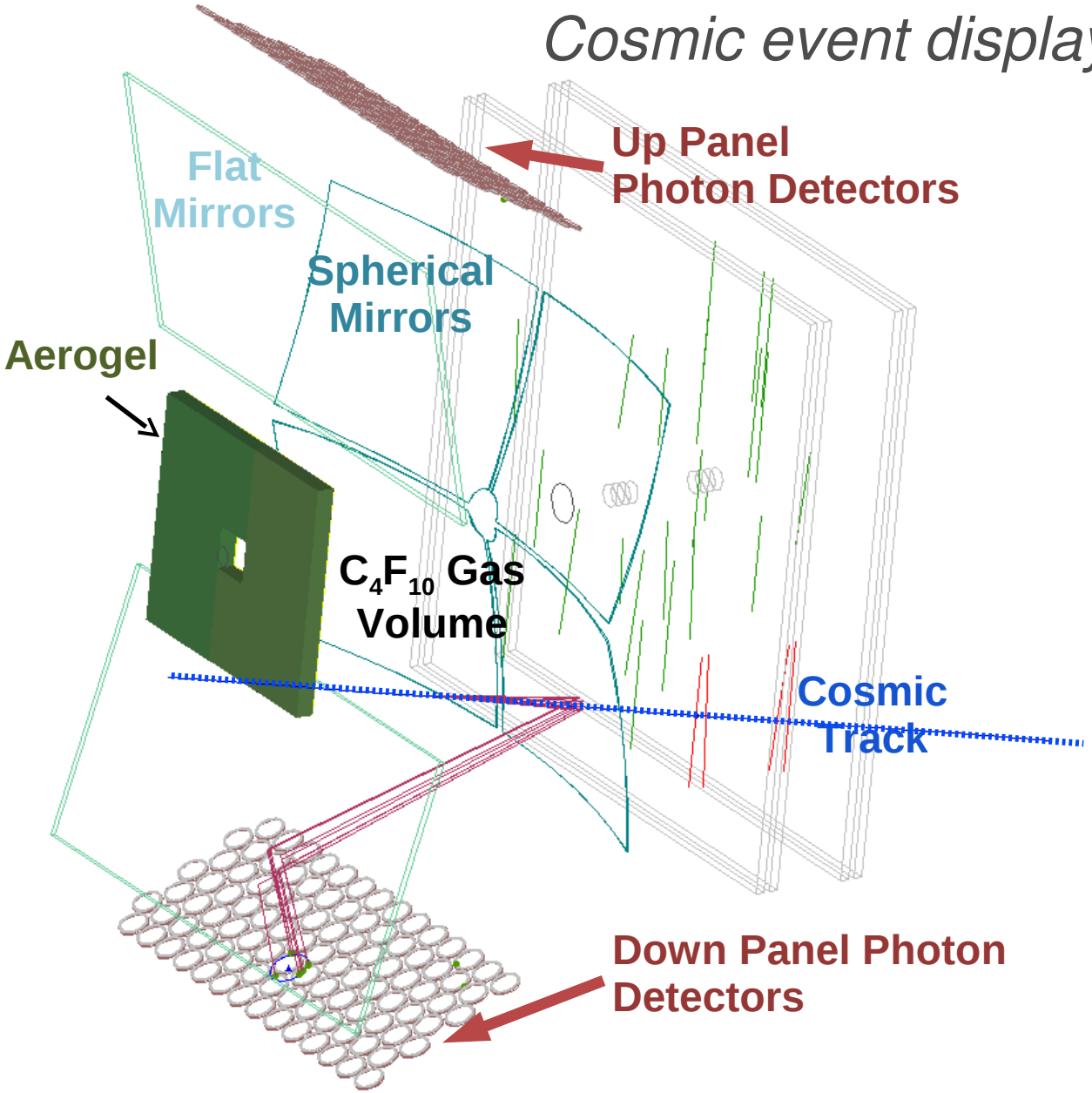
- RICH2 rotated by 90°
- detectors planes outside tracking acceptance (flat mirrors)



	RICH1	RICH2
Detector Planes	2 (*Horizontal*)	2 (*Vertical*)
Photon Detectors	2×7×14 = 196	2×9×16 = 288
Flat Mirrors	16	40
Spherical Mirrors	4	56

RICH1 detector in action

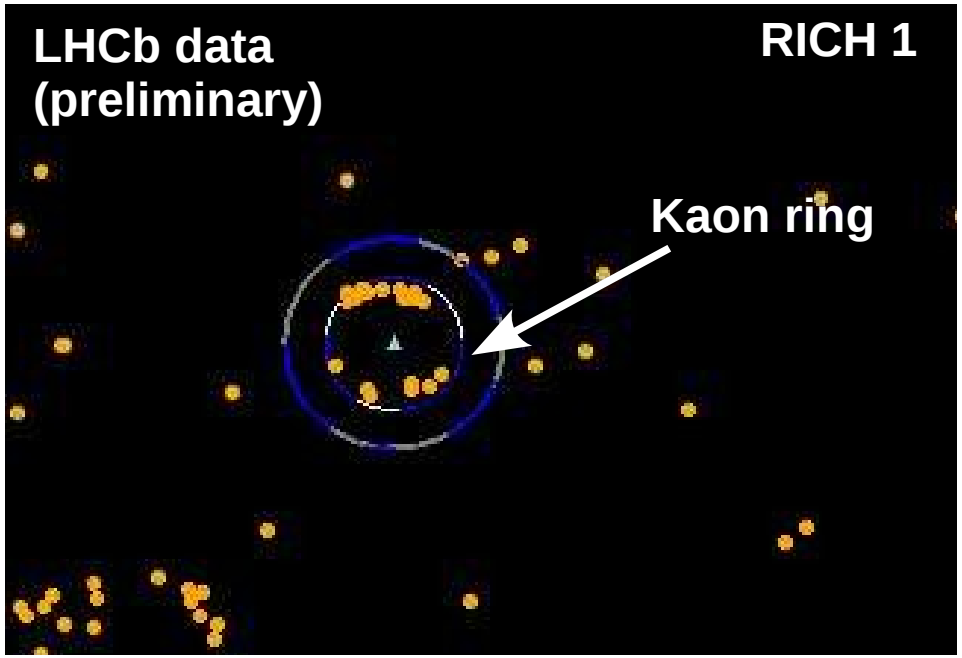
Cosmic event display

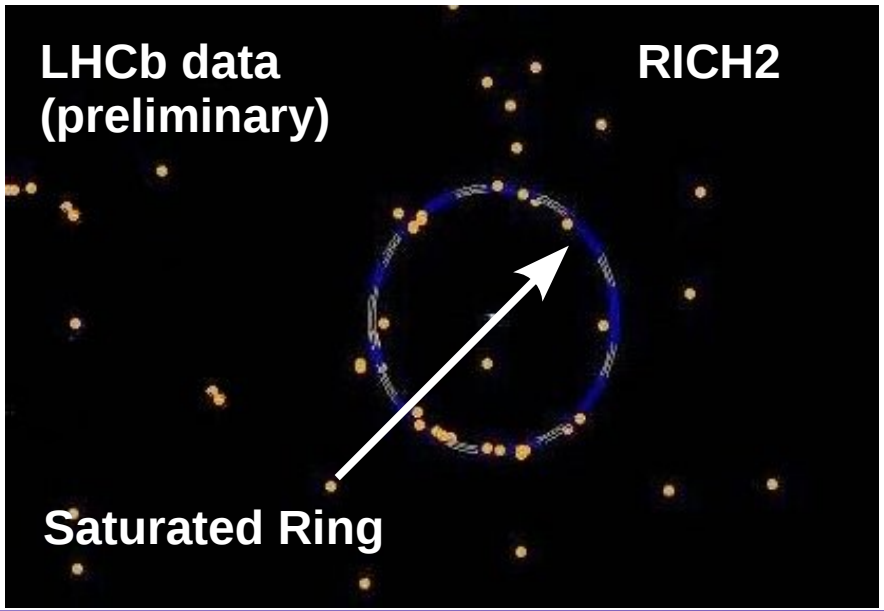


A charged track emits a **cone of Cherenkov light** on passing through the radiators (**Aerogel** & **C_4F_{10} Gas**).

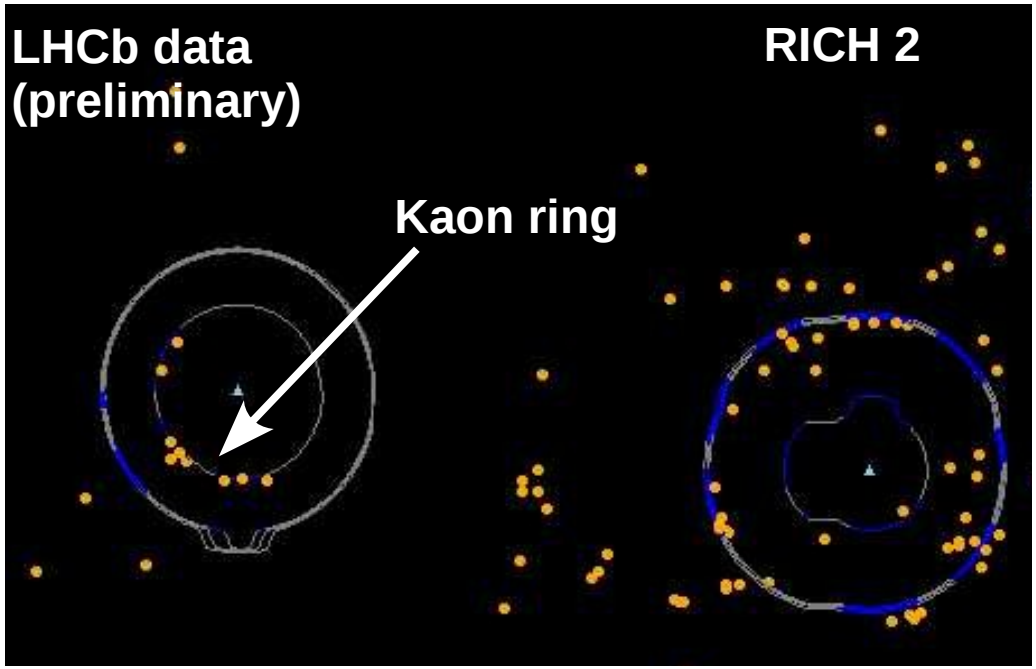
Mirrors focus these cones into rings on 2 **banks of photon detectors** positioned out of LHCb acceptance.

RICH Event Display





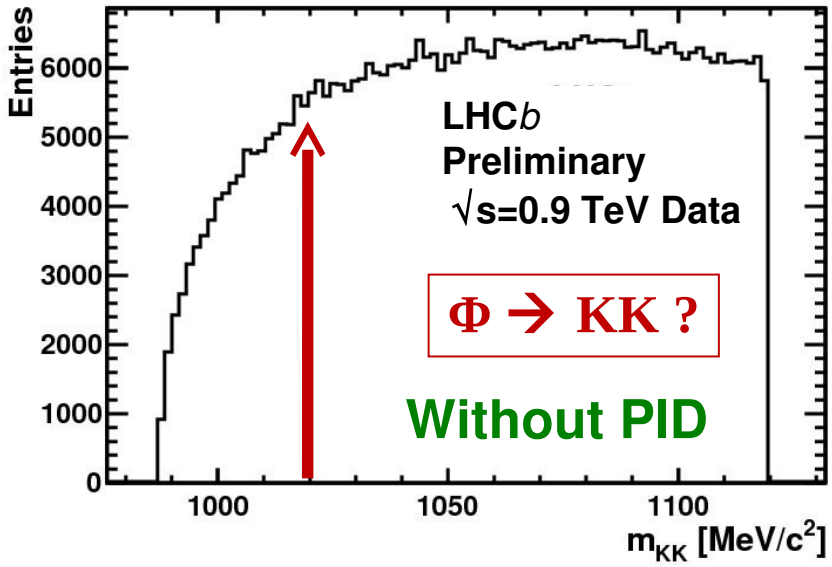
Nov/Dec 2009
LHC beams $\sqrt{s}$ = 900 GeV

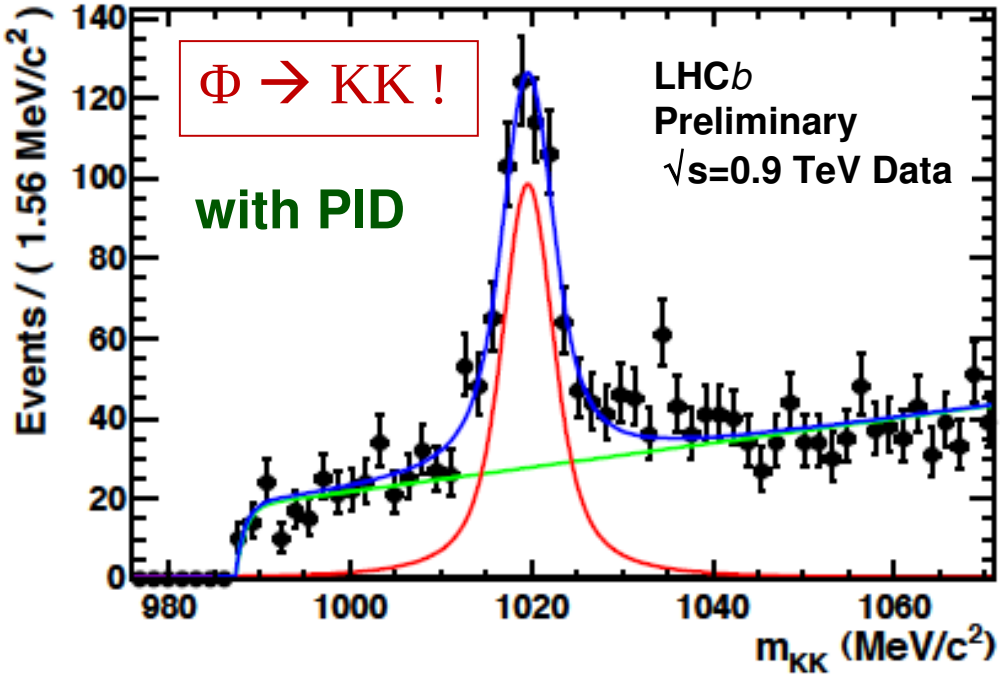


RICH Event Display:
Detected signals:
Photon hits shown in yellow points
Information from reconstruction:
Expected rings for given hypothesis and ray-traced photons shown in white lines and blue points

Particle Identification in the data

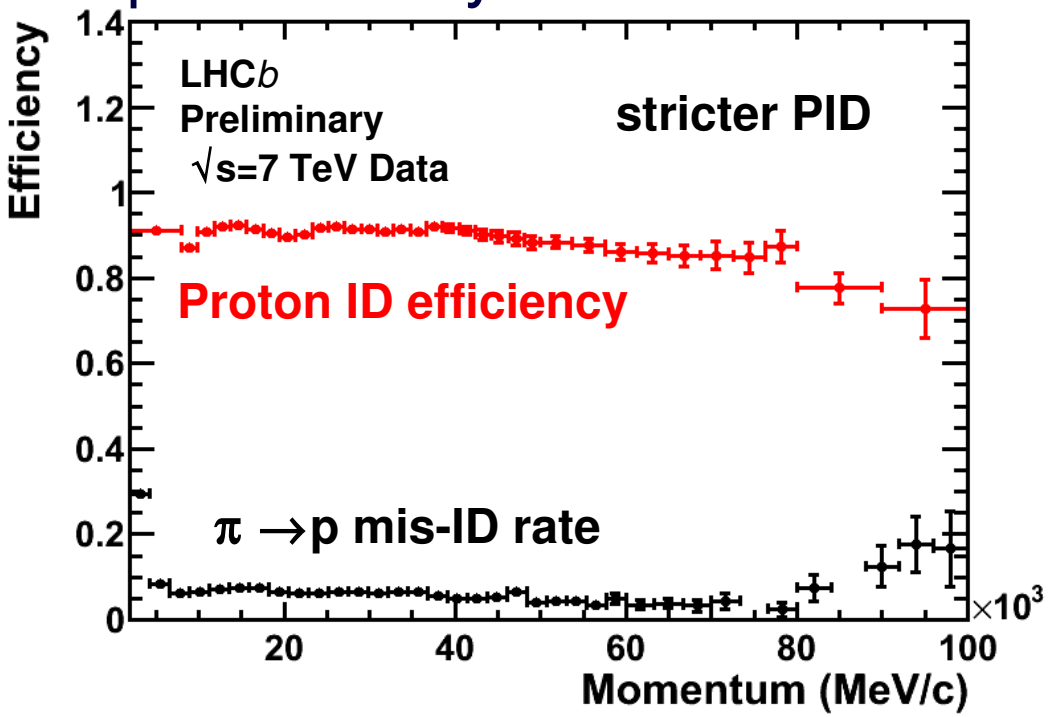
- for PID need to look at all tracks and photons at the same time
- maximize event likelihood for photon distribution by changing mass hypotheses for the tracks
- use mass hypotheses of best event likelihood
- to improve purity:
  require large change in the event likelihood for a change of mass hypothesis for a given track

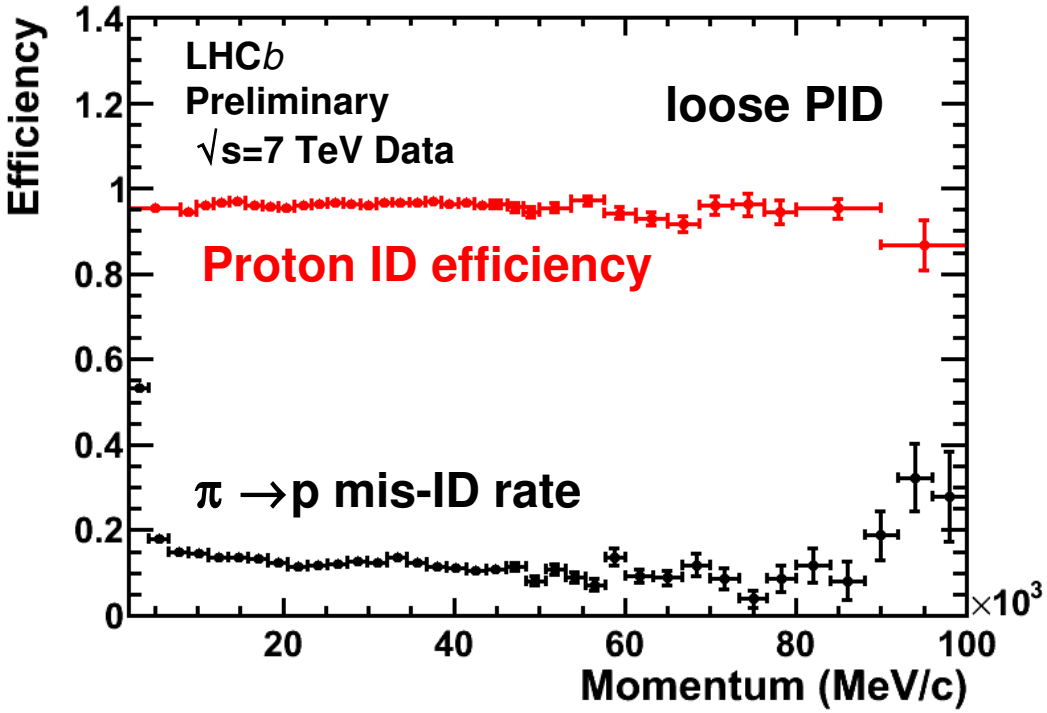




Study of RICH performance

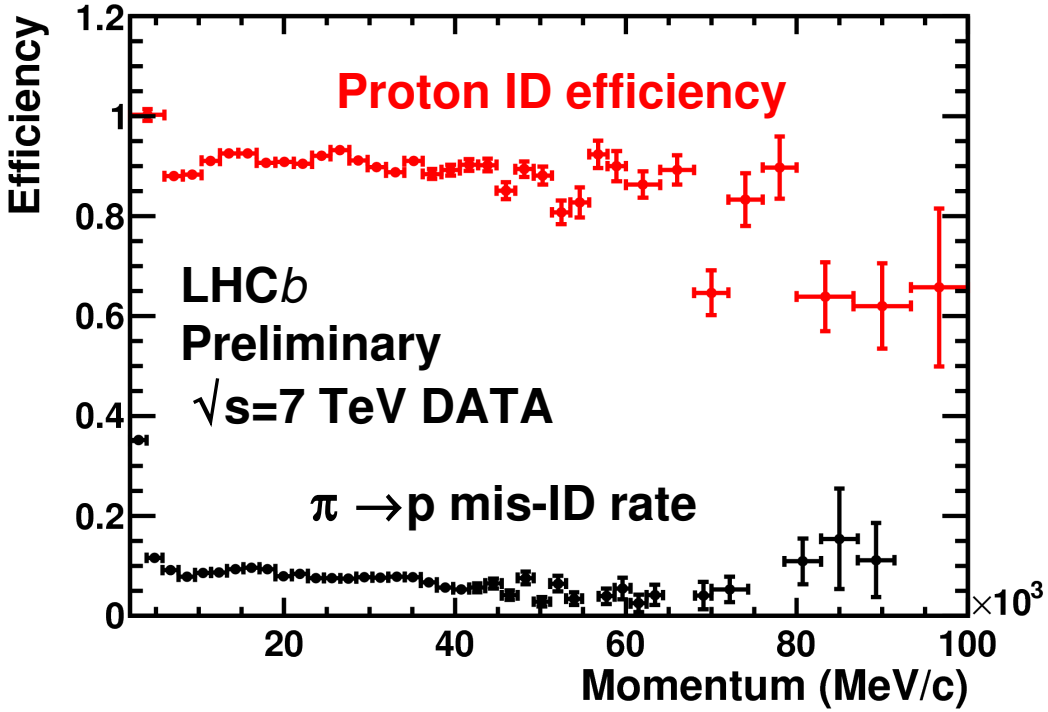
- use known resonances to measure PID performance
- π: Λ, K_S - decays
- K: Φ decays with one identified K
- p: Λ - decays

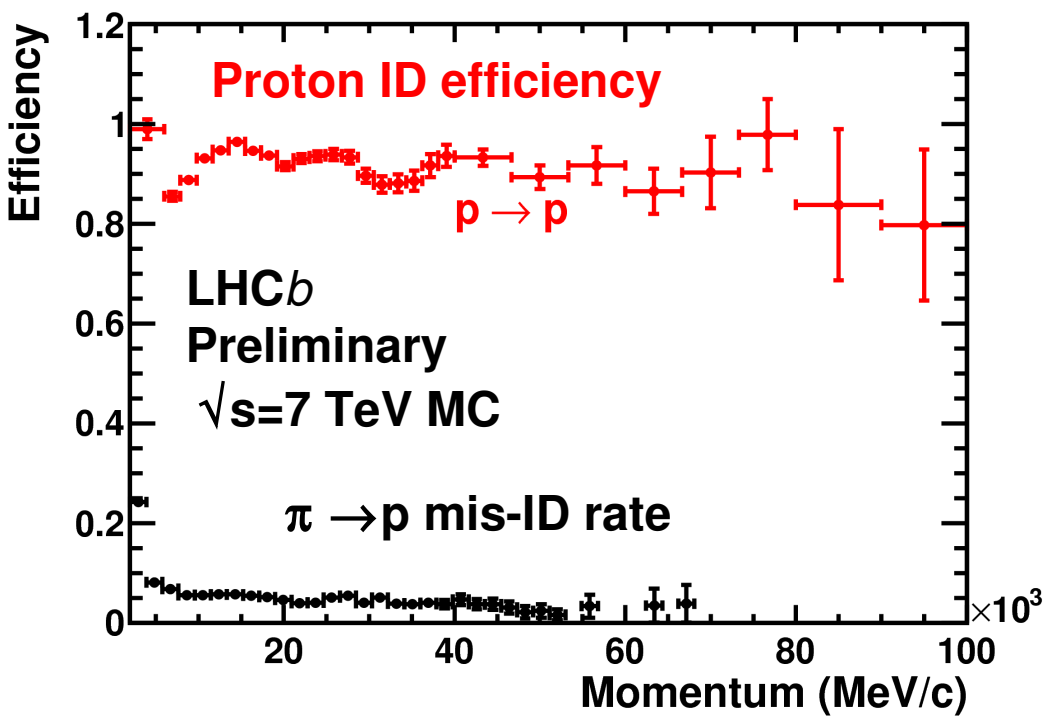




- preliminary calibration used in analysis
- loose PID selection
- purity improved with stricter cuts

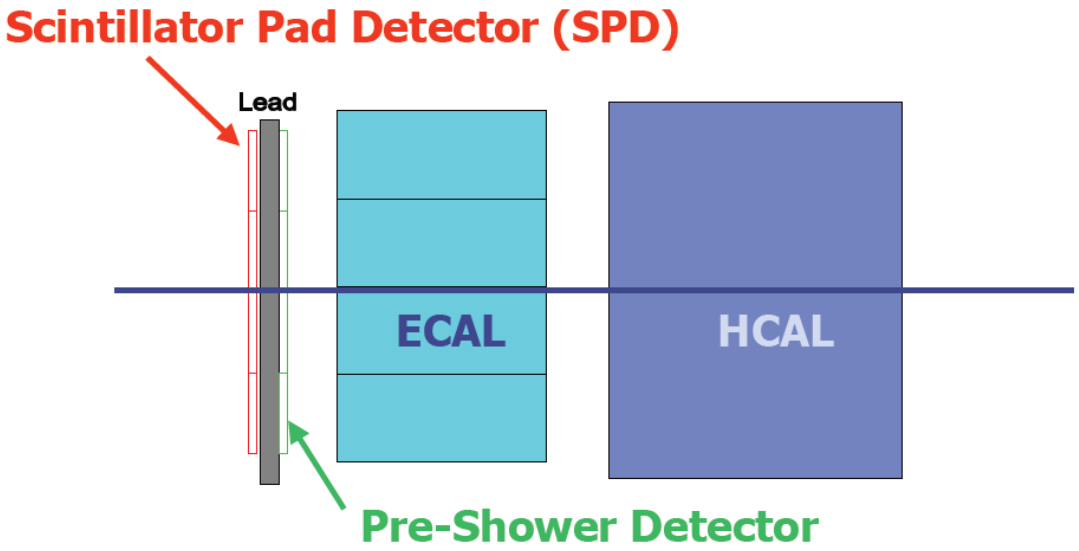
Comparison with PID in MC

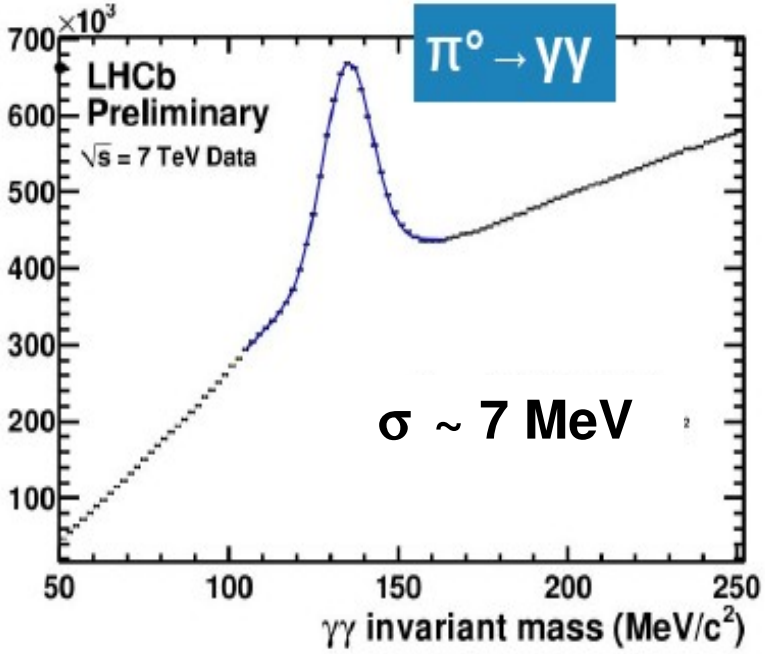




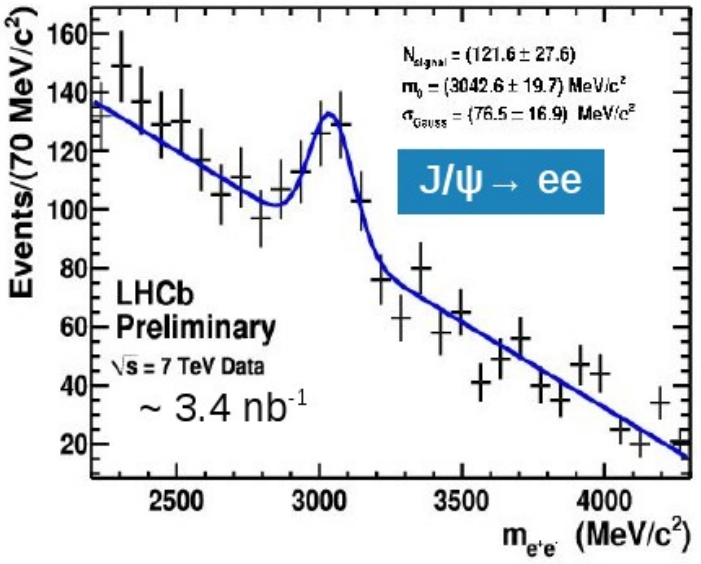
- only preliminary calibration and alignment used
- very good agreement between data and MC

Particle ID in calorimeters

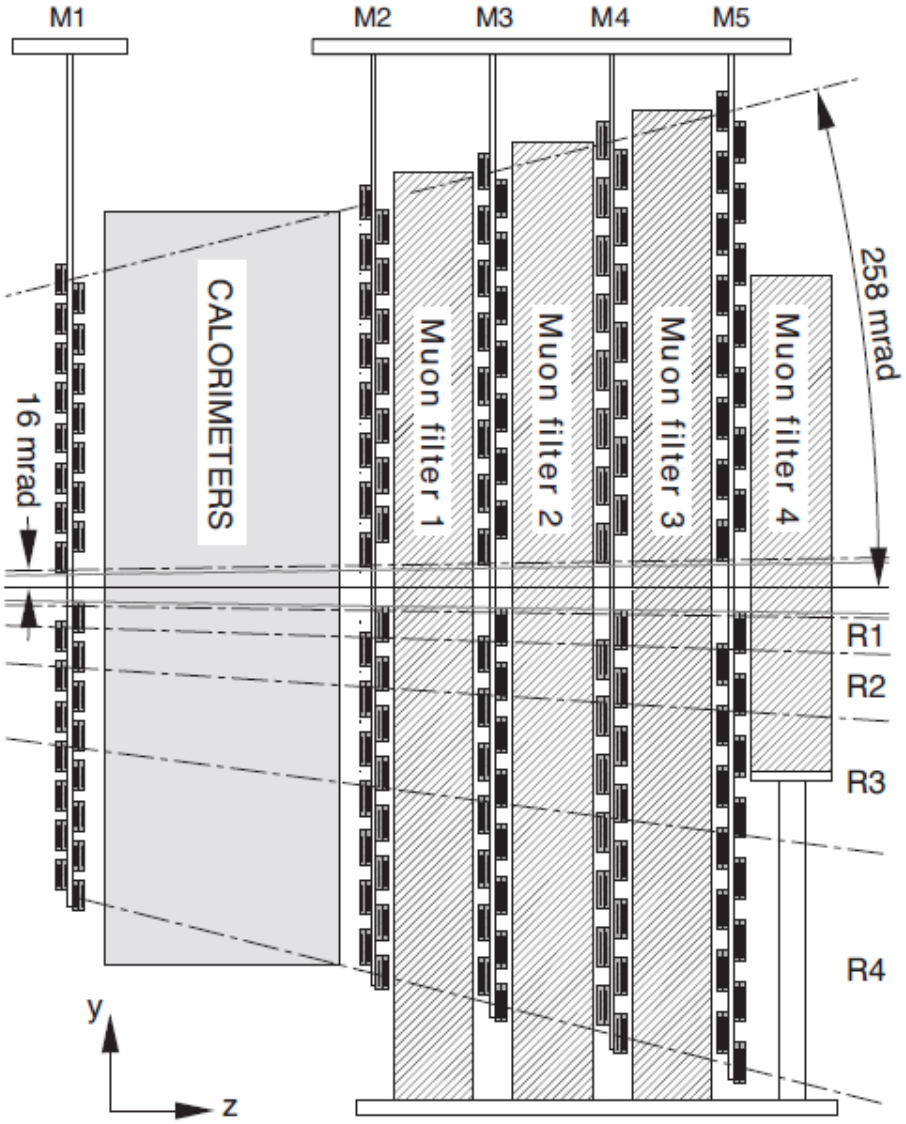




- particle identification based on energy deposits in different calorimeters
- PID performance depends on energy resolution
- for electrons (E/p-cut): 90% efficiency and 5% mis-ID
- very good agreement with MC



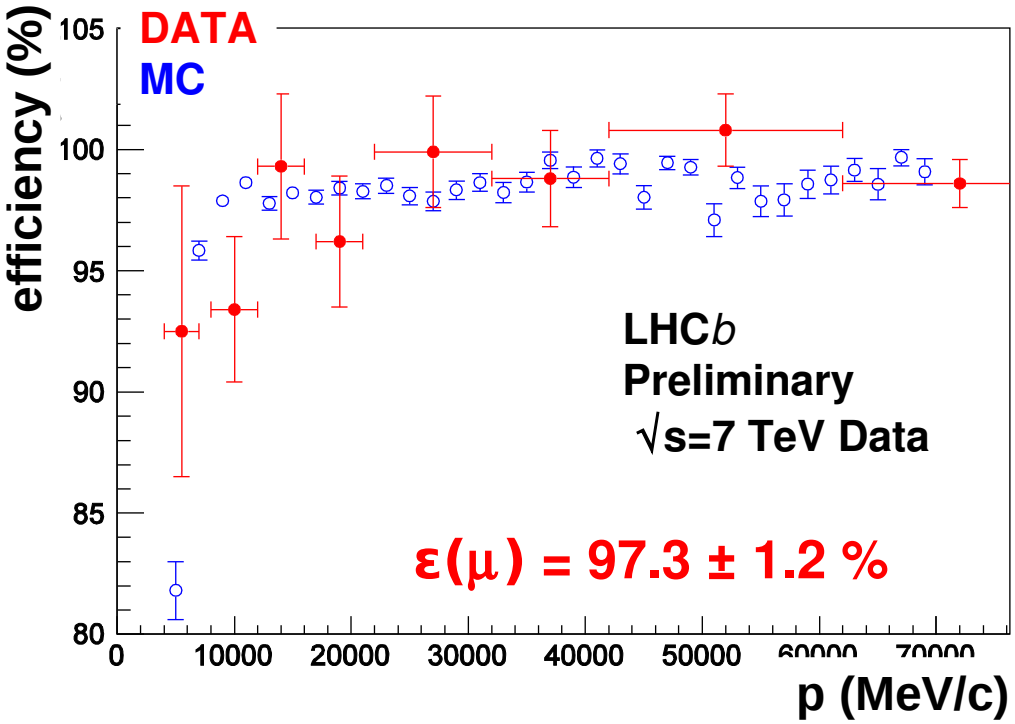
The Muon System

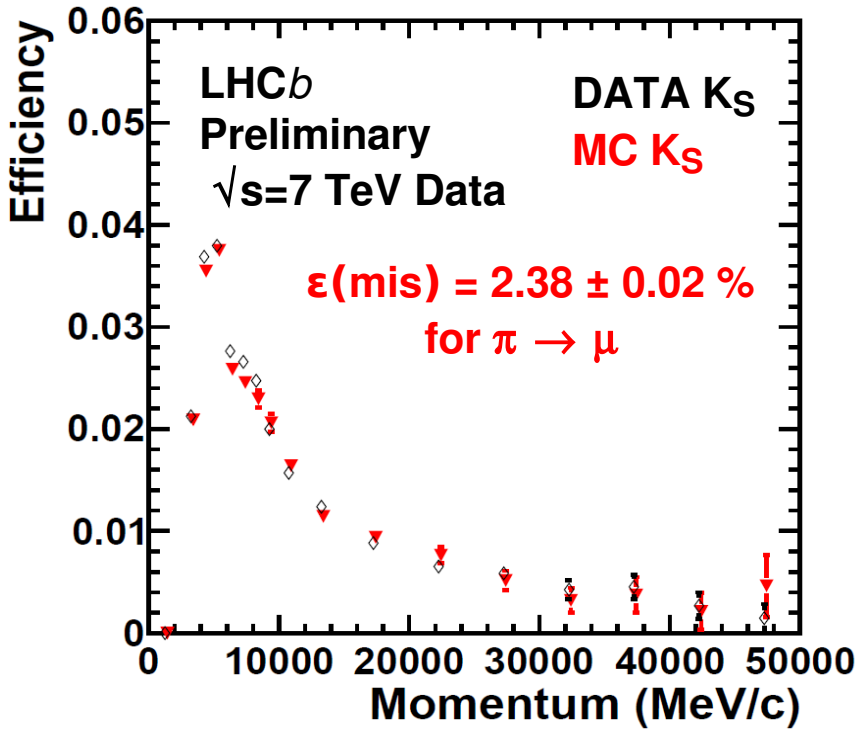


- 5 tracking stations around hadron absorbers (~ 23λ)
- Multi Wire Proportional Chambers (MWPCs) and Gas Electron Multipliers (GEMs)
- provides μ-ID with very high purity

μ-Identification

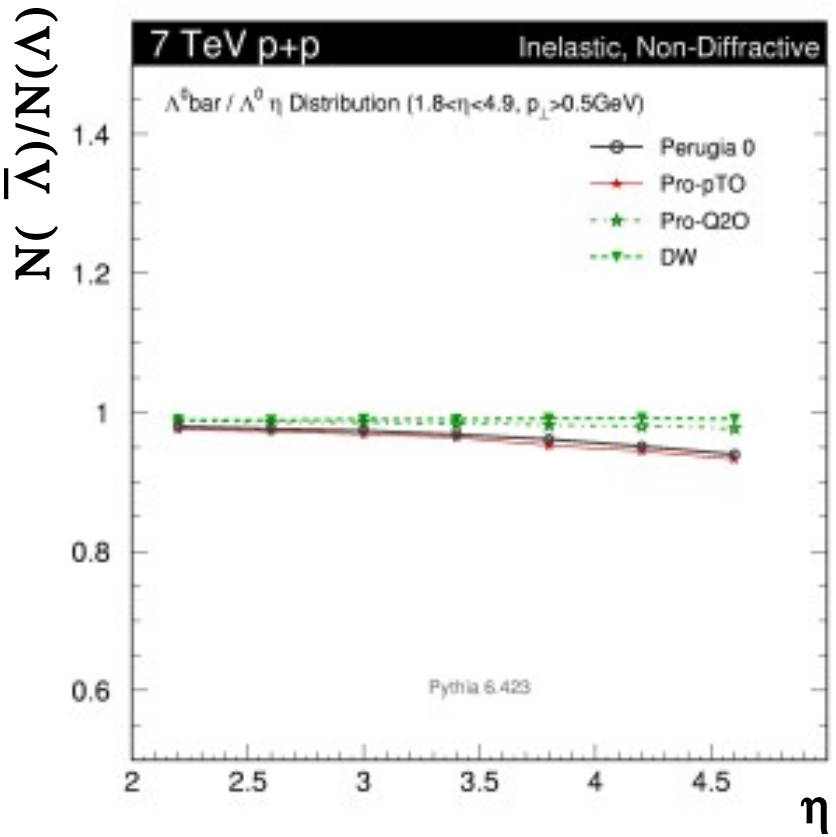
- extrapolate track to μ–system and look for hits in μ-stations
- a μ–candidate needs several hits in region of track impact point
- calculate probability based on hit distribution in μ-stations
- performance studied with J/ψ for μ-ID
- use π/K/p from decays to look at mis-ID rate

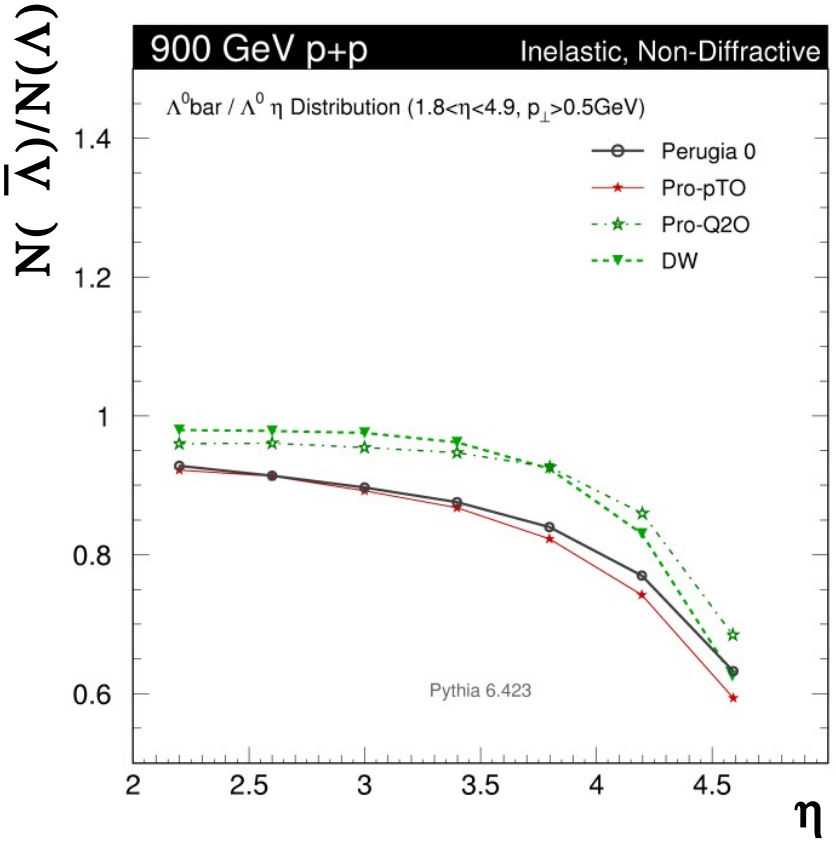




Baryon asymmetries

- Study of baryon number transport in pp-collisions
- expectation for p & Λ similar
- Λ baryon: sea-quark contribution
- existing models tuned to lower energies



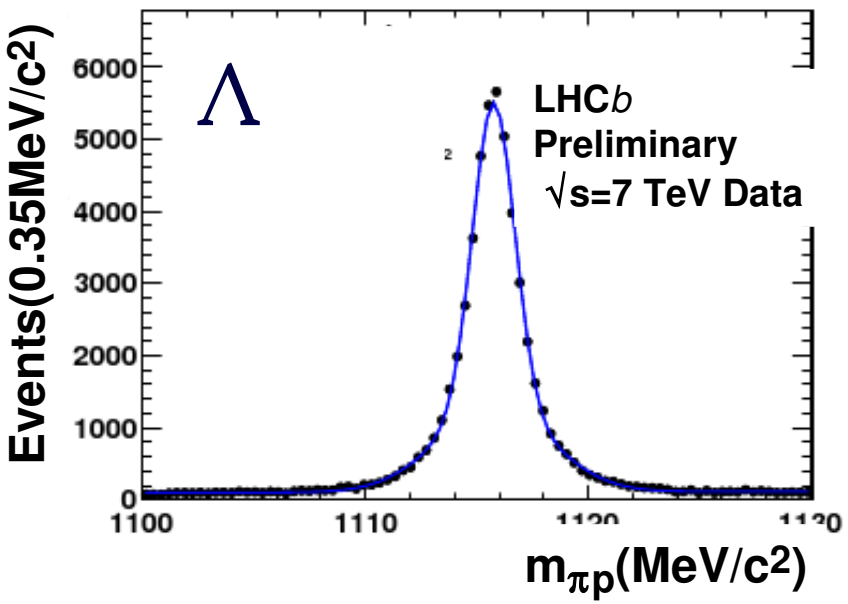


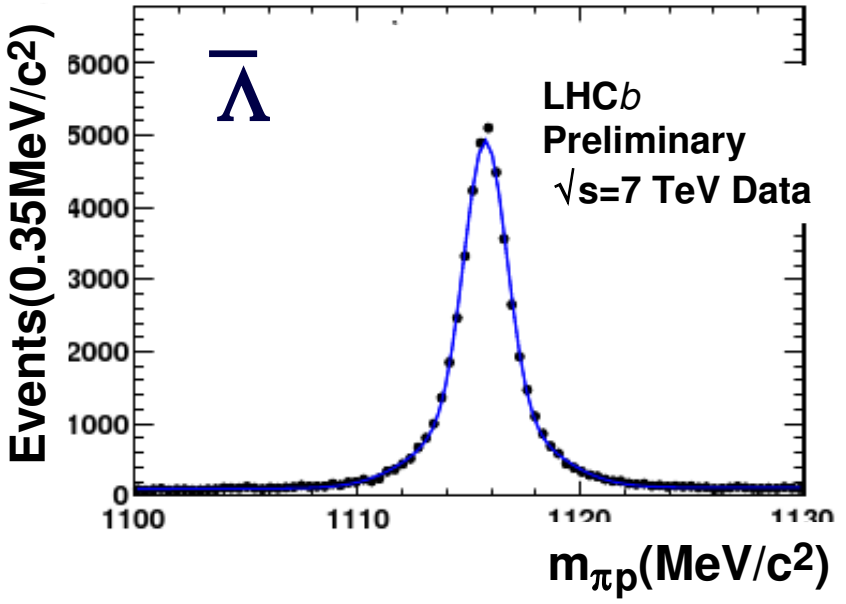
http://home.fnal.gov/~skands/leshouches-plots/

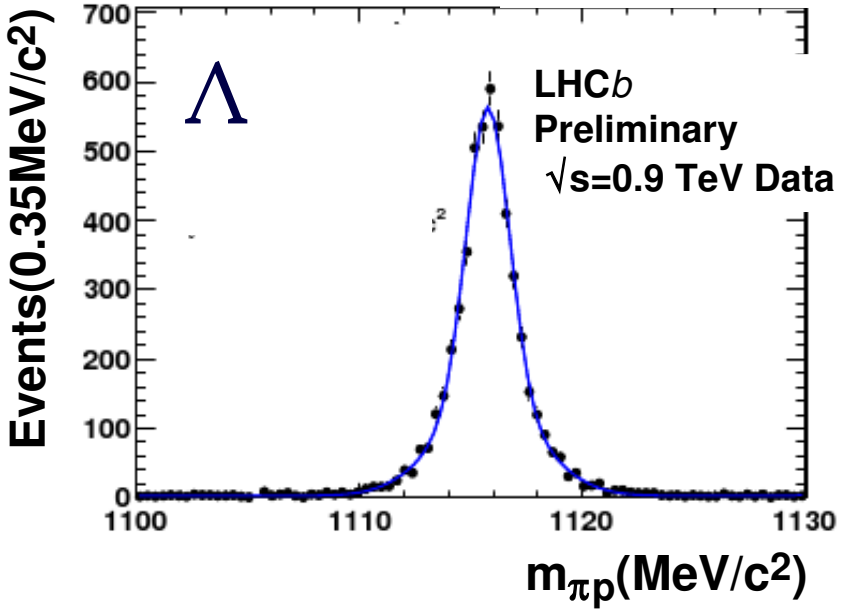
Event Selection

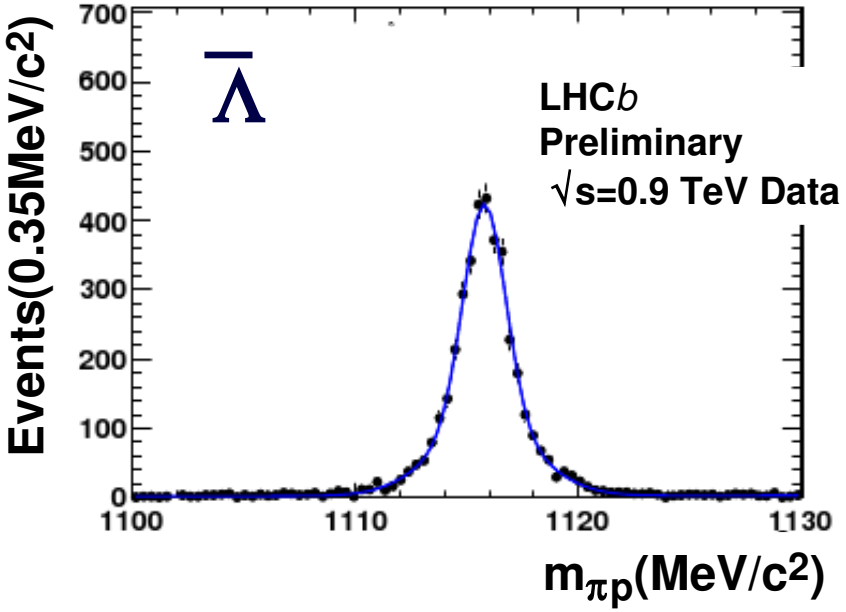
- at least 1 primary vertex in interaction region
- select only good quality long tracks
- **Λ selection: $\Lambda \rightarrow p\,\pi$**
  - prompt Λ: pointing to primary vertex
  - Λ selected by the Armenteros-Podolansky variable
  - RICH PID not used
  - combinatorial background in Λs reduced with cuts on ratio of impact paratmeters ($IPp \cdot IP\pi / IP_{\Lambda}$) and on decay angle
- **2 data sets: $\sqrt{s}$=0.9 TeV: 0.31nb^{-1}**
  - **Λ:** 9224 Λ and 6802 $\bar{\Lambda}$
    - **$\sqrt{s}$=7 TeV: $\leq$1nb^{-1}**
  - **Λ:** 45605 Λ vs 41192 $\bar{\Lambda}$

Λ Invariant Mass Distributions

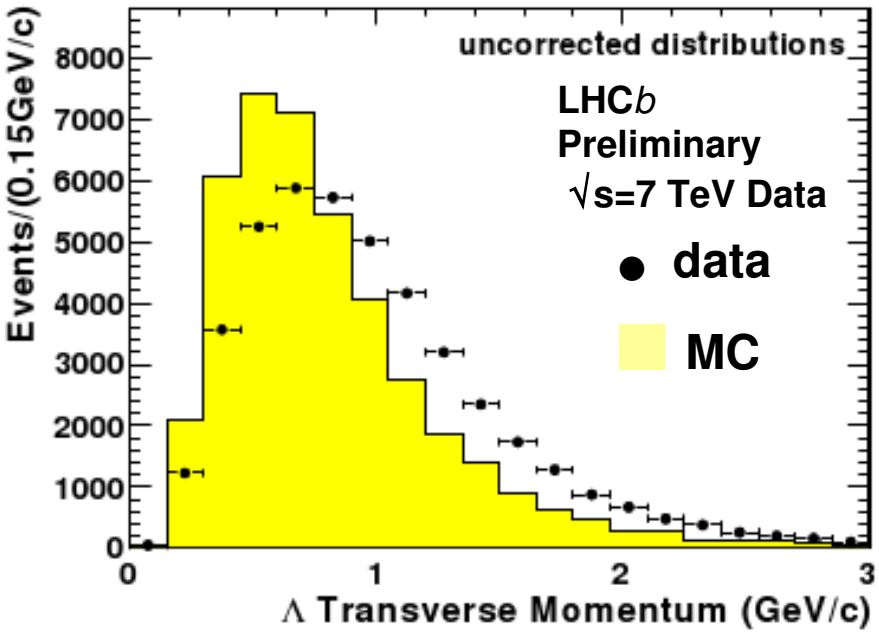


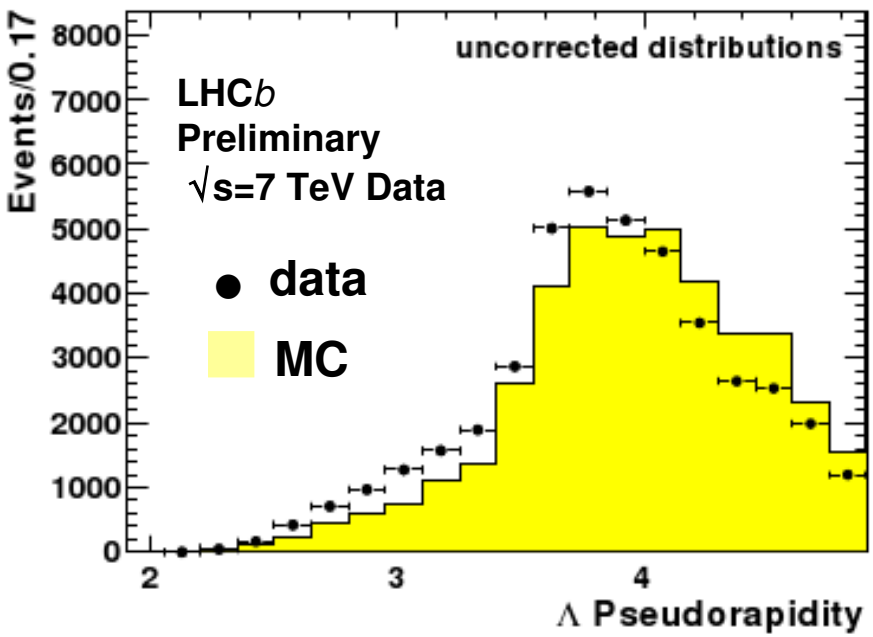


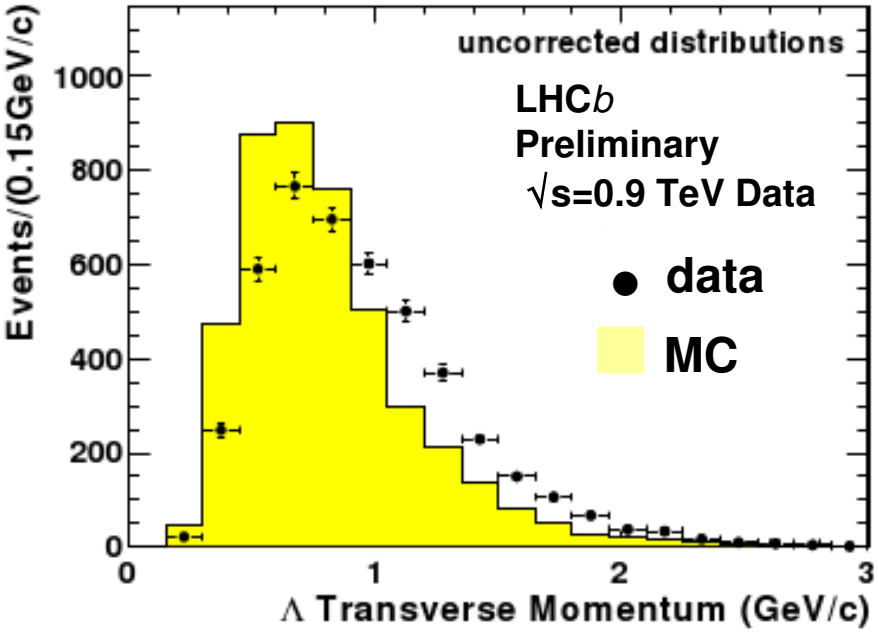


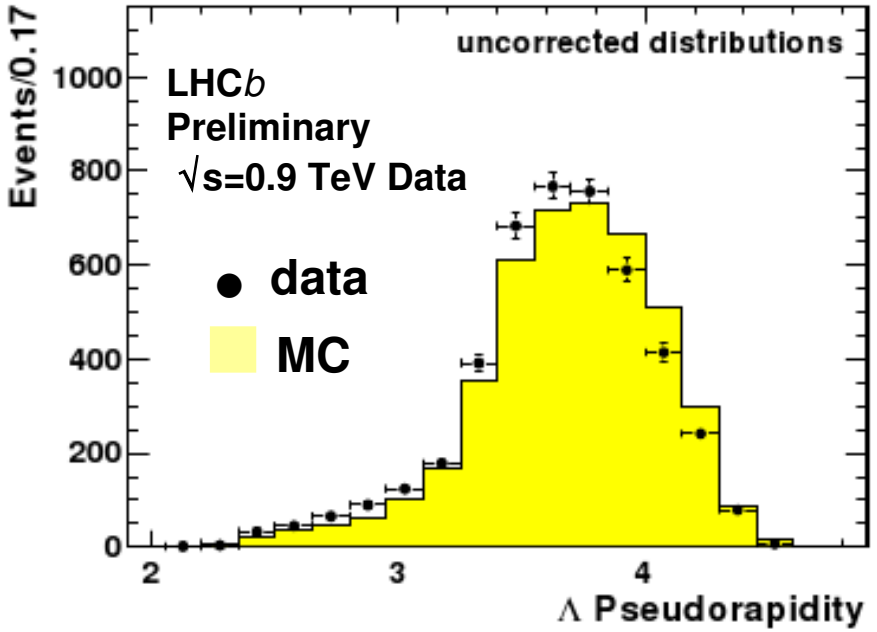


Looking at Λ - kinematics





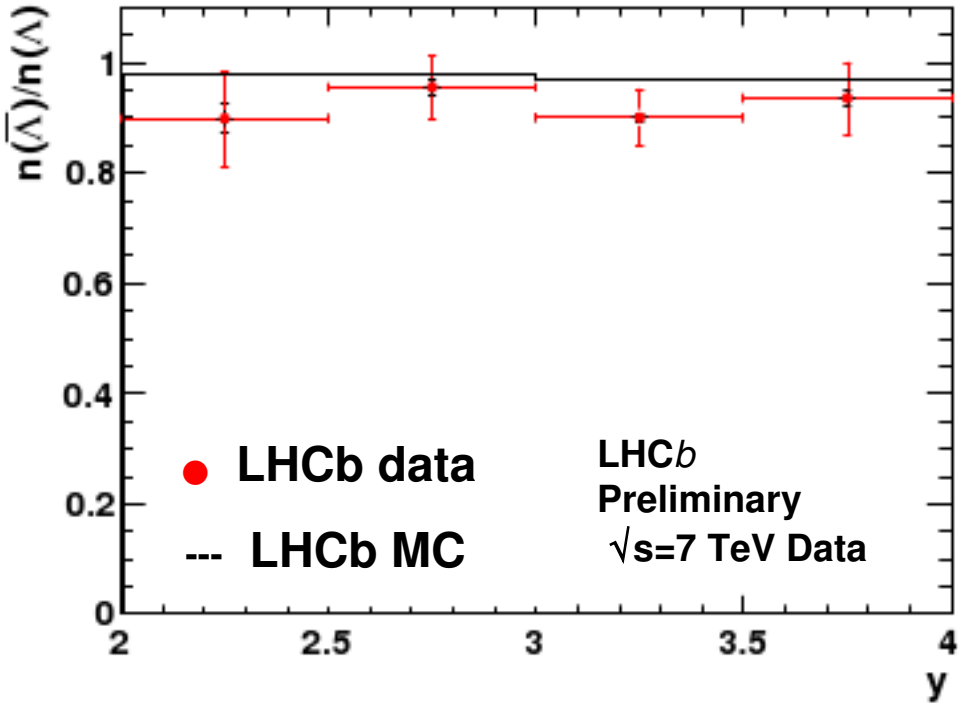




Measuring Baryon Asymmetries

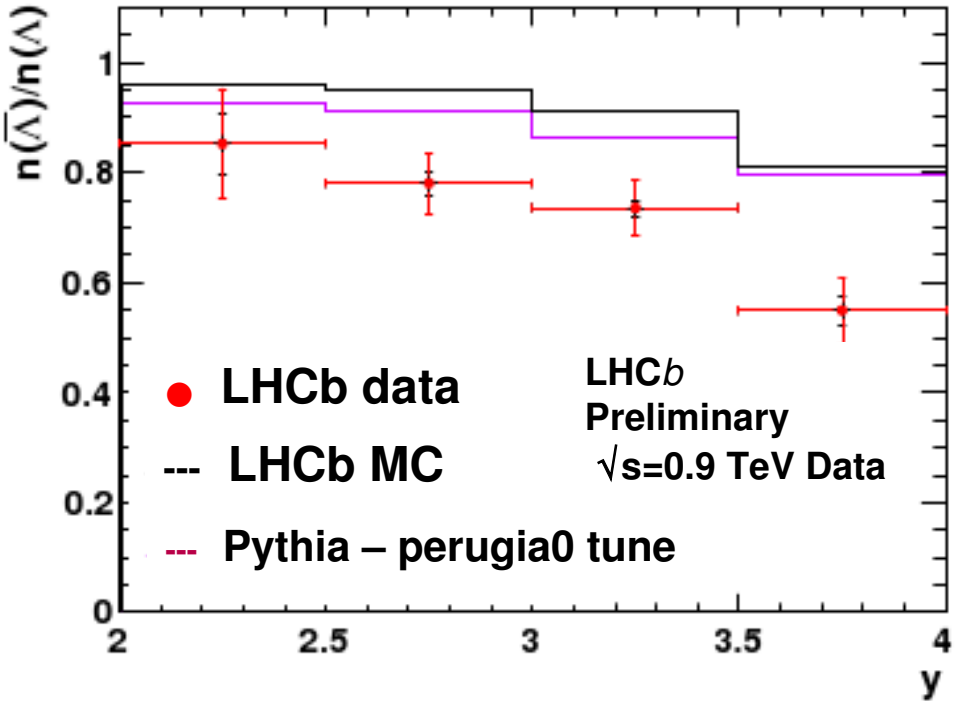
- Determine **raw asymmetries** from number of observed particles and anti-particles in a given bin
  - use sideband subtraction to correct for background
- Correct raw asymmetries for:
  - Detector acceptance effects: efficiencies, material interactions and more (from detector simulation)
- Look at **corrected asymmetries** in bins of y and p_T
- Main contributions to **systematic errors**:
  - Uncertainty in acceptance corrections taken from Monte Carlo (material interactions)
  - Possible contribution from non-prompt and diffractive baryon production (below percent level)

Results for $\bar{\Lambda}/\Lambda$



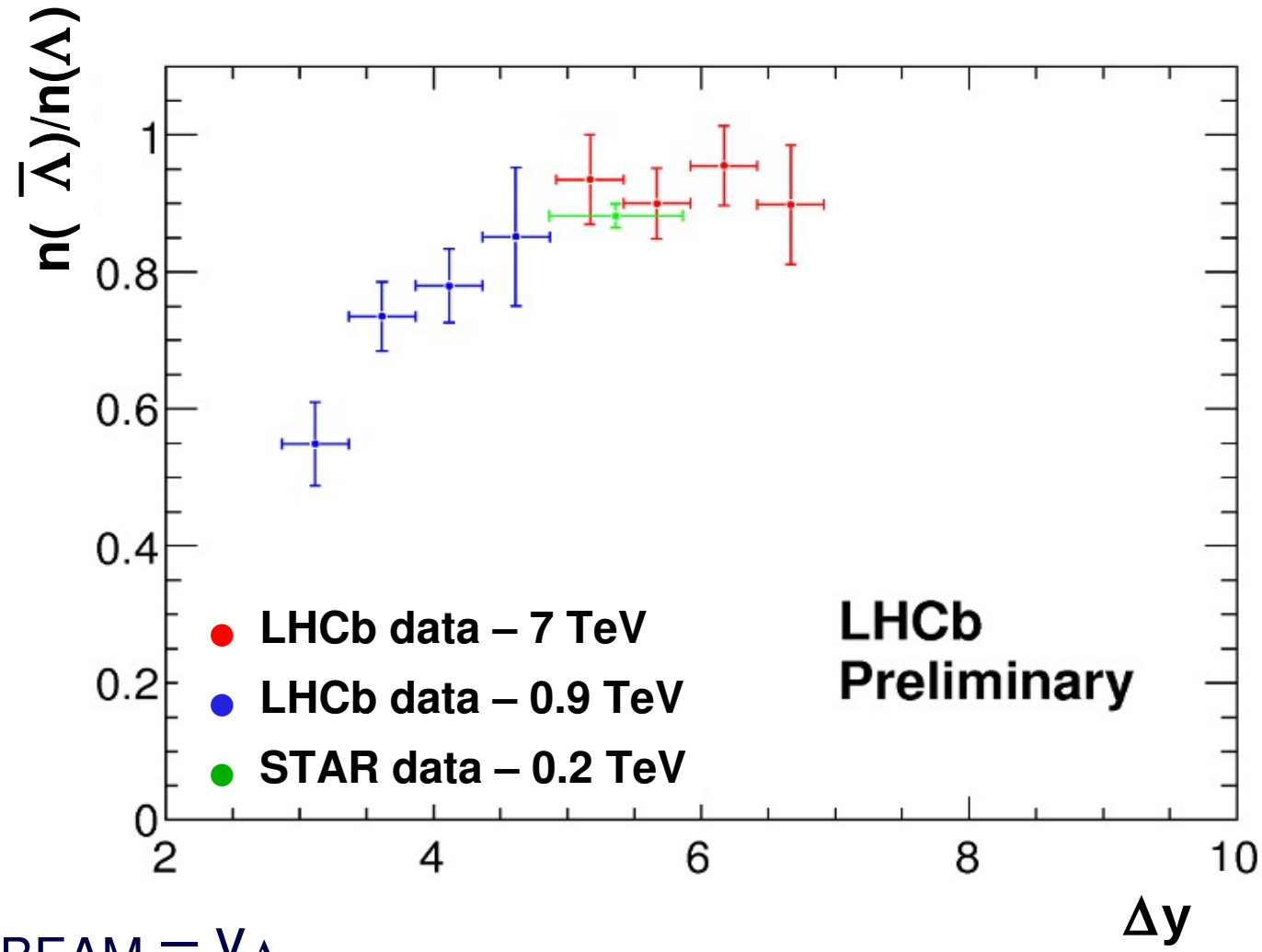
- high energy data good agreement to MC
- low energy data significantly below MC

→ look at y(beam) - y(Λ)



MC models:
Perugia tunes do not include diffraction
LHCb tune include diffraction (<1% after selection cuts)

Results for $\bar{\Lambda}/\Lambda$

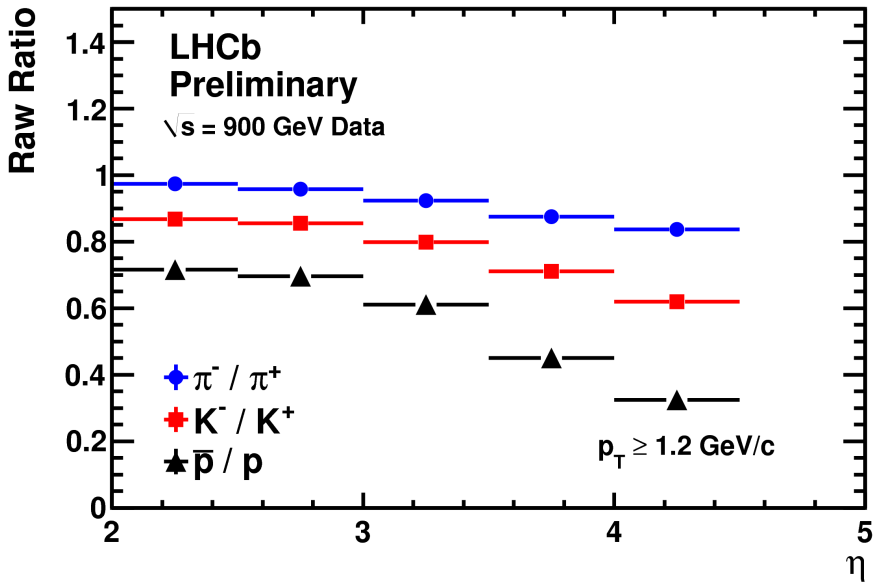


$\Delta y = y_{BEAM} - y_{\Lambda}$

y_{BEAM}=8.345 for 7 TeV y_{BEAM}=6.556 for 0.9 TeV

Proton production asymmetry

- use PID information from the RICH detectors to select protons → cuts tuned to obtain purity>90% in acceptance
- parallel analysis for π/K and p
- correct raw p and $\bar{p}$ rates for PID efficiency and purity → obtained from analysis of control channels
- need to correct raw asymmetries for acceptance effects, in particular material interaction
- study contribution from diffractive and non-prompt interaction
- analysis being finalised, full results at ICHEP



Conclusion

- Particle ID in LHCb is in very good shape
- all systems show good performances in agreement with expectations from Monte Carlo simulation
- measurement of baryon asymmetry for prompt Λ production shown
- results for $\sqrt{s}$=0.9 TeV show larger asymmetry than expected from MC predictions
- agreement of $\sqrt{s}$=7 TeV data with MC is better
- measurement of baryon asymmetry for prompt p production being finalised